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STEP STRESS TESTING PROGRAM

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FINAL REPORT
FOR
JANTX1N2989B

FEBRUARY 1979

Prepared
For

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FOREWORD

This is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS was to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of varieties of discrete devices, as well as to determine which type of stress should be applied to a particular type of device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.



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1.0 INTRODUCTION

DCA Reliability Laboratory, under contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of Semiconductor devices. This report covers the zener diode JANTX2N2989 manufactured by Siemens and General Semiconductor.

A total of 48 samples from each manufacturer was submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 high-speed computer-controlled tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_z and the current was varied in order to comply with the specified power rating for this device. At least one of the devices was subjected to maximum rated power (MRP). All the remaining devices were subjected to no less



than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the power stress process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150, and 175 percent of maximum rated power for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1.

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subject to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in a sample lot failed.* Electrical measurements were

Conditions for failure:

- A) Open or short.
- B) Leakage exceeds the maximum limit by 100 times.
- C) Other parameters exceed MIL limits by 50% or more.



performed on all specified electrical parameters after each temperature step. See Table 1.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Siemens. The Siemens sample lot completed 1650 hours of Group I Testing before the lot was stopped because of 50% of the devices failed. The first failure occurred 150 hours into the 100% MRP step. Serial number 9326 failed the maximum I_R limit. The next failure occurred 150 hours into the 125% MRP step. Serial number 9325 failed the maximum I_R limit. The next three failures occurred 500 hours into the 125% MRP step. Serial numbers 9319, 9321, and 9323 failed the maximum I_R limit. The next failure occurred 10 hours into the 150% MRP step. Serial number 9330 failed the maximum I_R limit. The last two failures occurred 150 hours into the 150% MRP step. Serial numbers 9320 and 9333 failed the maximum B_V limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 188.96nA from an initial mean of 12.34nA to a final mean of 201.3nA.
- 2) The mean value for B_V changed 0.79V from an initial mean of 30.28V to a final mean of 31.07V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 General Semiconductor Inc. (G.S.I.). The G.S.I. sample lot completed 2000 hours of Group I Testing before the lot was stopped because 50% of the devices failed. The



first four failures occurred 500 hours into the 125% MRP Step. Serial numbers 9375, 9376, and 9379 failed the maximum I_R limit. Serial number 9382 failed the maximum B_V limit. The next failure occurred 50 hours into the 150% MRP step. Serial number 9388 failed the maximum B_V limit. The next two failures occurred 250 hours into the 150% MRP step. Serial numbers 9373 and 9387 failed the maximum B_V limit. The last failure occurred 500 hours into the 150% MRP step. Serial number 9384 failed the maximum I_R limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 1.11mA from an initial mean of 17.39nA to a final mean of 1.11mA.
- 2) The mean value for B_V changed 0.13V from an initial mean of 29.93V to a final mean of 30.06V.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I

Table 4 outlines the results of Group I - Power Stress Testing for each of the electrical parameters and all of the measurement points pertaining to both Siemens and G.S.I.

3.2 Group II - Temperature Stress I

- ### 3.2.1 Siemens.
- The Siemens sample lot completed 800 hours of Group II Testing before the lot was stopped because more than 50% of the devices failed. The first seven failures occurred 160 hours into the 150°C-temperature step. Serial numbers 9394, 9397, 9398, 9399, 9400, 9402, and 9403 were removed from the Group II Testing



as visual catastrophic failures.* The last failures occurred 160 hours into the 175°C-temperature step. Serial numbers 9392 and 9395 were removed from the Group II Testing as visual catastrophic failures.* Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 48.60nA from an initial mean of 1.77nA to a final mean of 50.37nA.
- 2) The mean value for B_V changed 0.32V from an initial mean of 30.60V to a final mean of 30.28V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2

General Semiconductor Inc. (G.S.I.). The G.S.I. sample lot completed 960 hours of Group II Testing before the lot was stopped because more than 50% of the devices failed. The first failure occurred 160 hours into the 100°C-temperature step. Serial number 9350 was removed from the Group II Testing as a visual catastrophic failure.* The next two failures occurred 160 hours into the 150°C-temperature step. Serial number 9343 failed the maximum I_R limit. Serial number 9345 was removed from the Group II Testing as a visual catastrophic failure.* The last seven failures occurred 160 hours into the 200°C-temperature step. Serial numbers 9318, 9339, 9341, 9344, 9347, 9348, and 9349 were removed from the Group II Testing as visual catastrophic failures.* Typical characteristics of this sample lot's performance were:

* See Note "C" in Table 8.



- 1) The mean value for I_R changed 77.38nA from an initial mean of 6.19nA to a final mean of 83.57nA.
- 2) The mean value for B_V changed 0.62V from an initial mean of 30.81V to a final mean of 31.43V.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II

Table 5 outlines the results of Group III - Temperature Stress I Testing for each of the electrical parameters and all measurement points for both Siemens and G.S.I.

3.3 Group III - Temperature Stress II

3.3.1 Siemens. The Siemens sample lot completed a total of 80 hours of Group III Testing before the lot was stopped because more than 50% of the devices failed. The first failure occurred 16 hours into the 200°C-temperature step. Serial number 9317 failed the maximum B_V limit. Serial number 9364 was also removed from the Group III Testing as a MIL-STD-19500 B_V maximum limit failure. The next five failures occurred 16 hours into the 225°C-temperature step. Serial numbers 9351, 9354, 9355, 9357, and 9360 failed the maximum B_V limit. The last nine failures occurred 16 hours into the 250°C-temperature step. Serial numbers 9363 and 9365 failed the maximum I_R limit. Serial numbers 9352, 9356, 9358, 9359, 9361, 9362, and 9366 failed the maximum B_V limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 1.91mA from an initial mean of 587.70μA to a final mean of 2.50mA.



- 2) The mean value for B_V changed 6.33V from an initial mean of 30.58V to a final mean of 24.25V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 General Semiconductor Inc. (G.S.I.). The G.S.I. sample lot completed the entire 112-hour Group III Testing with 10 catastrophic failures. The first six failures occurred 16 hours into the 250°C-temperature step. Serial number 9406 failed the maximum I_R limit. Serial numbers 9408, 9411, 9415, 9416, and 9417 failed the maximum B_V limit. The last four failures occurred 16 hours into the 300°C-temperature step. Serial numbers 9405, 9407, 9414, and 9418 failed the maximum I_R limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 4.54mA from an initial mean of 4.28nA to a final mean of 4.54mA.
- 2) The mean value for B_V changed 8.23V from an initial mean of 30.20V to a final mean of 21.97V.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III

Table 6 outlines the results of Group III - Temperature Stress II Testing for each of the electrical parameters and all measurement points for both Siemens and G.S.I.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The



graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160) hours and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2 and 4. Figures 2 & 4 were used as a source for the graphs in Fig. 3 and 5 respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0

CONCLUSIONS

All three stress groups proved detrimental to both Siemens and G.S.I. In Group I and III Testing, the G.S.I. and Siemens devices were electronically intact but damaged mechanically. Electrical readings were obtained by probing the die. The bonded die connections were damaged and the cathode detached when the part was opened. This suggests that the devices failed due to excessive temperature.

The failure mode in the Group II Testing for both manufacturers was visual catastrophic. The failed parts have cracked glass and detached cathodes caused by the excessive temperature, which also resulted in the disconnection of the internal wire lead.



A plot showing cumulative failure distribution for Group II and III was drawn for the General Semiconductor sample lot (Figures 4 and 5), but, because of the visual catastrophic failures in the Group II Testing, the Siemens sample lot could not be drawn (Figures 2 and 3). Figures 4 and 5 display the data for the General Semiconductor sample lot used to calculate an activation energy of .91eV.

A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated failure point. The regression line was calculated using the least square method.

The activation energy was calculated from the formula:

$$E = \left[\ln \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \times 10^{-5} \text{ eV/}^{\circ}\text{K}}{\left(\frac{1}{T_1 + 273} \right) - \left(\frac{1}{T_2 + 273} \right)} \right] \text{ eV}$$

Where:

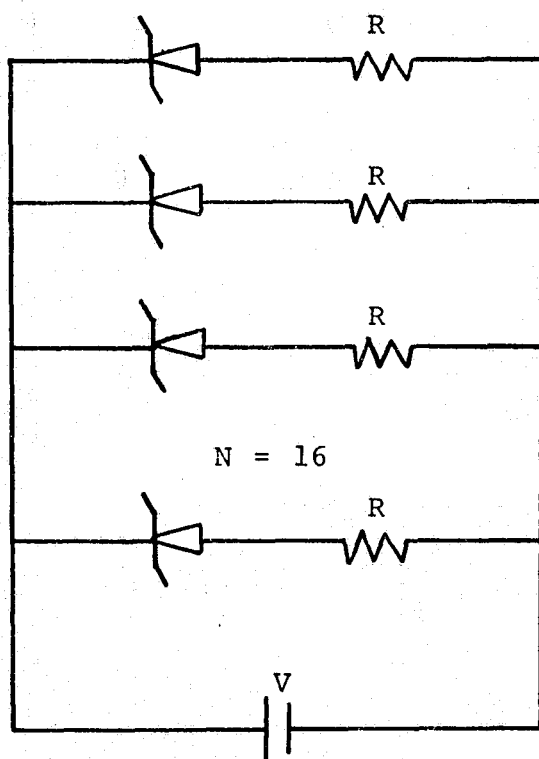
- t_1 = step of Group II - Temp Stress I = 160 hrs.
- t_2 = step of Group III - Temp Stress II = 16 hrs.
- T_1 = temperature in $^{\circ}\text{C}$ of 16% failure for Group II.
- T_2 = temperature in $^{\circ}\text{C}$ of 16% failure for Group III.



JANTX1N2989B

FIGURE 1

ZENER DIODES



$$R = V_Z \div 1.75 I_{Z_{MAX}} \pm 50\%$$

$$P_d = V_Z^2 \div R$$

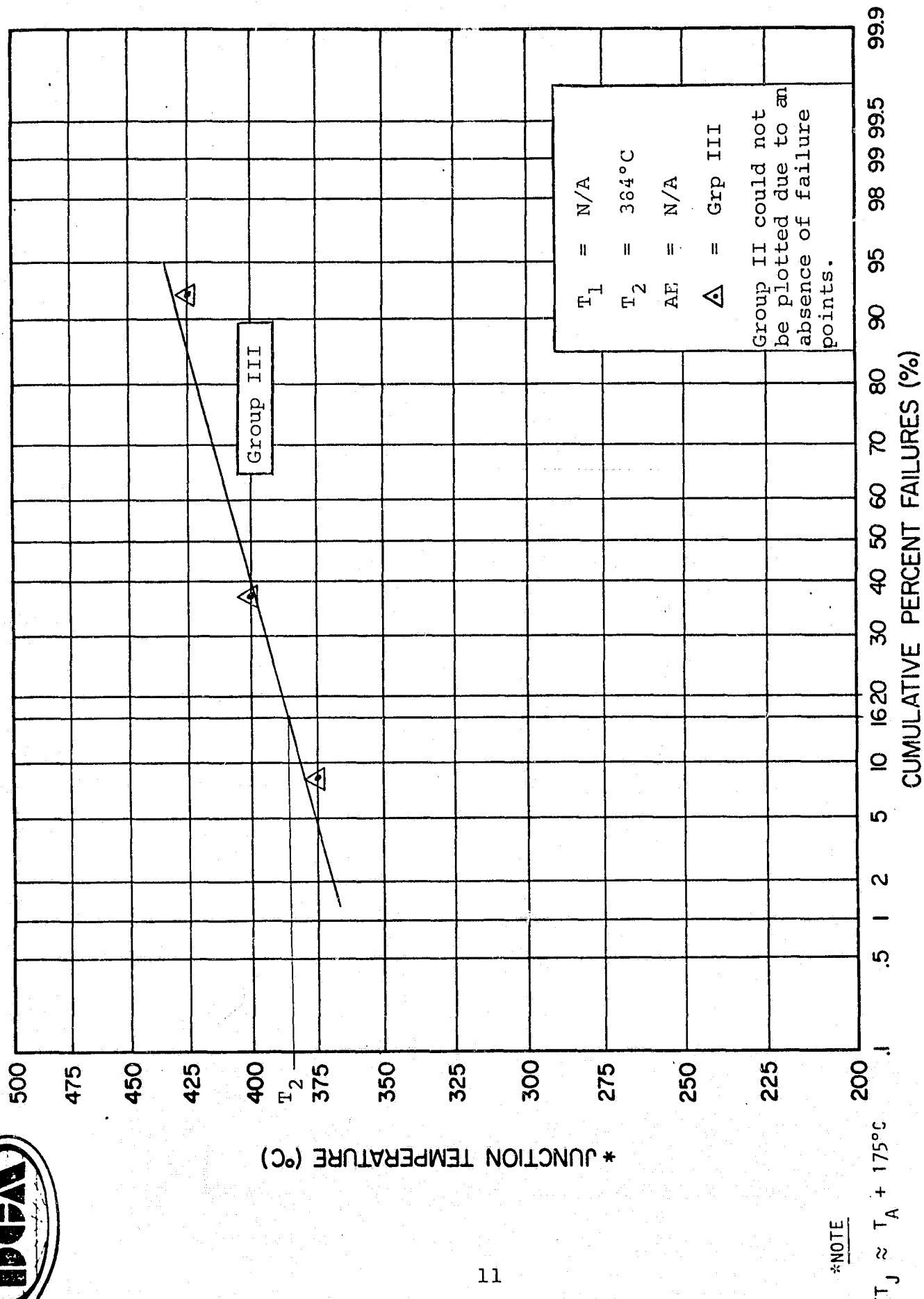
POWER/TEMPERATURE STRESS CIRCUIT
FOR JANTX1N2989B

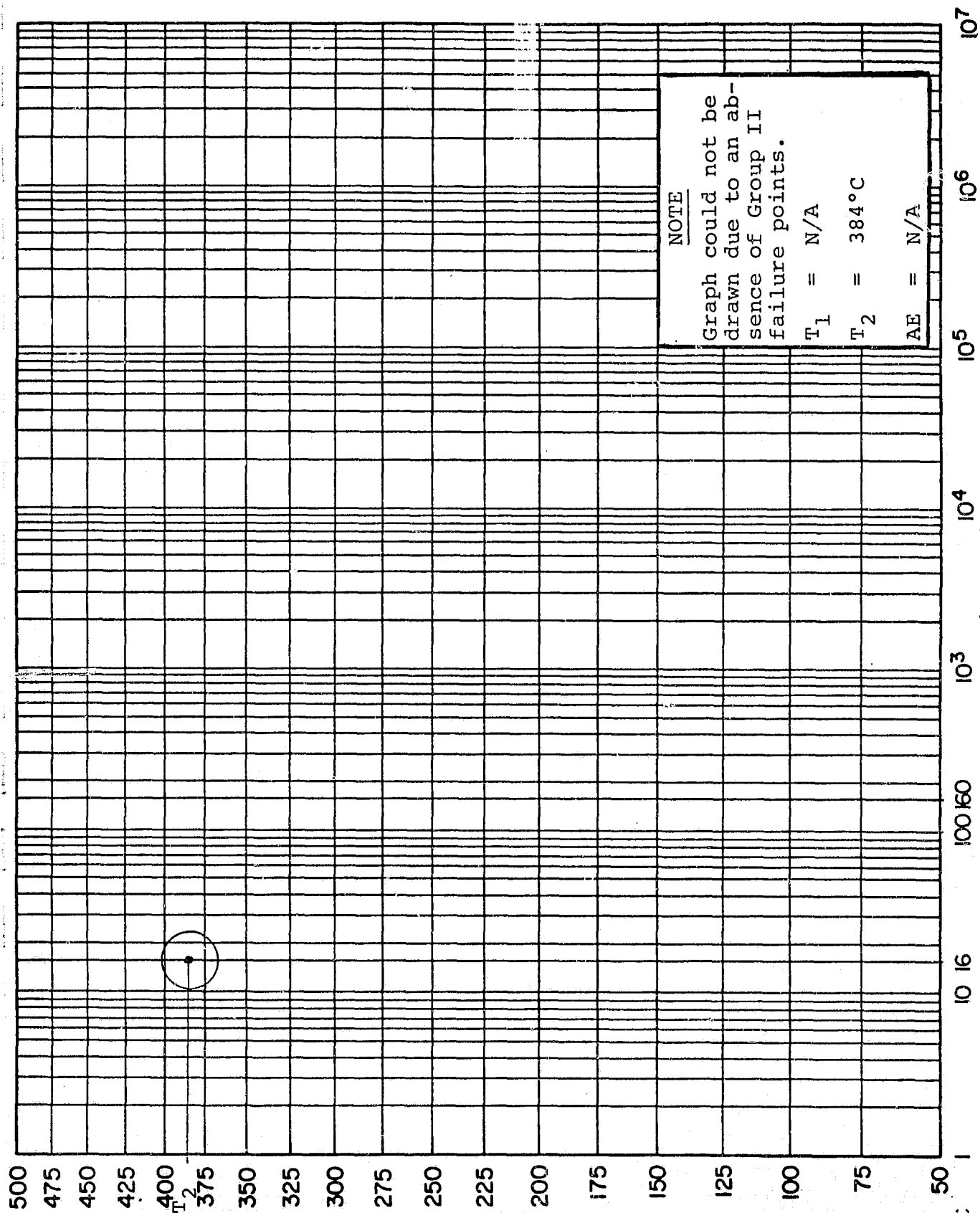


SIEMENS

JANTX1N2989B

JANTX1N2989B





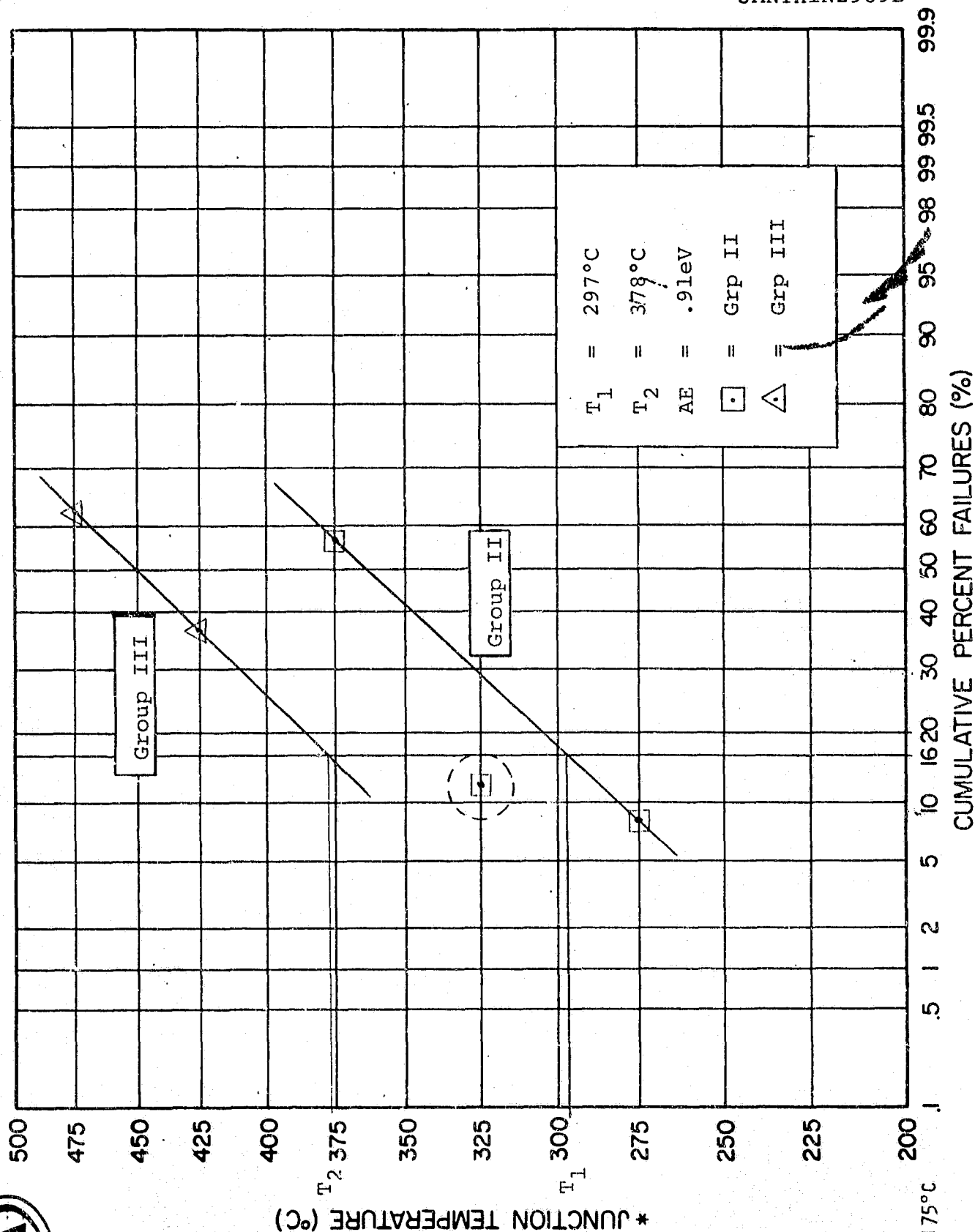
*NOTE

$$T_J \approx T_A + 175^\circ\text{C}$$

TIME (HOURS)

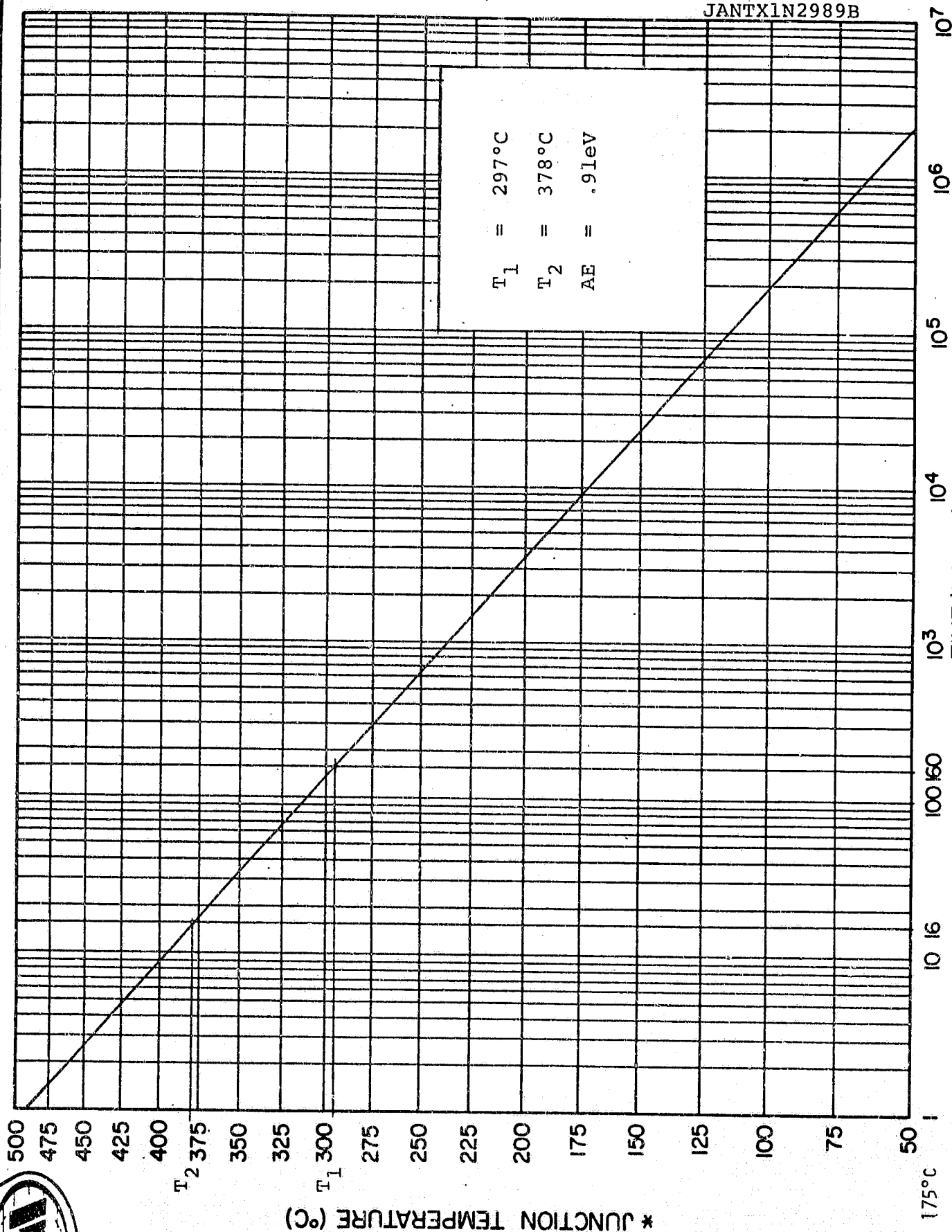
FIGURE 3

Time Steps Versus Junction Temperature, Siemens





JANTX1N2989B

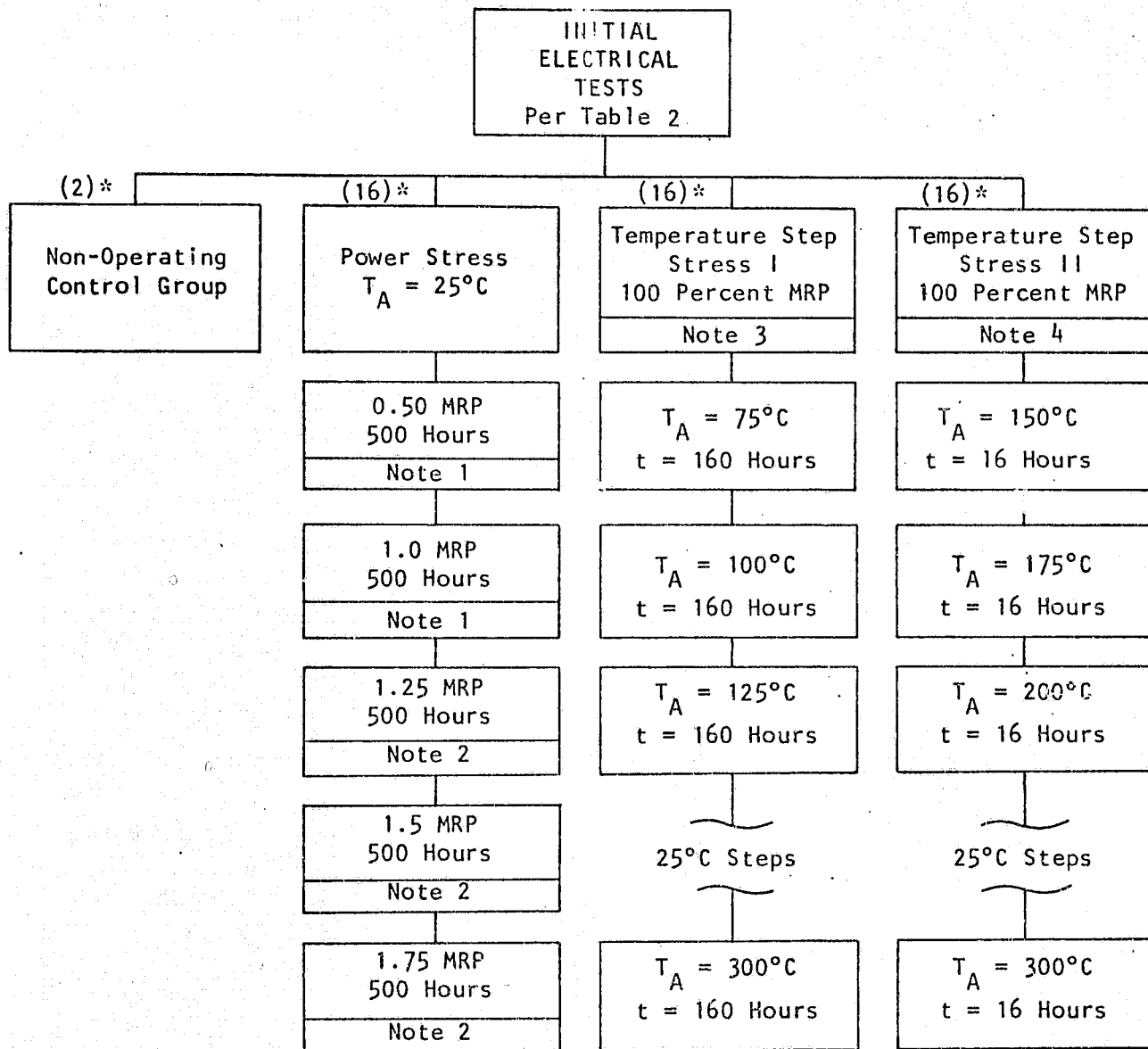


*NOTE

$$T_J \approx T_A + 175^\circ\text{C}$$

Time Steps Versus Junction Temperature, General Semiconductor

FIGURE 5

TABLE 1
TEST FLOW DIAGRAM

*Quantity per manufacturer (Siemens & General Semi-conductor, Inc.)

NOTES:

- 1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
- 2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
- 3) Electrical measurements per Table 2 were made at the end of each 160 hours.
- 4) Electrical measurements per Table 2 were made at the end of each 16 hours.



TABLE 2

PARAMETERS AND TEST CONDITIONS

DCA RELIABILITY LABORATORY

PARAMETER	CONDITIONS	SPEC LIMITS		CAT. LIMITS		UNITS
		MIN	MAX	MIN	MAX	
I_R	$@V_R = 22.8V$		10		1000	μA
B_V	$@I_Z = 85.0mA$	28.5	31.5	14.25	47.25	V
NOTES:						

TABLE 3
POWER STRESS BURN-IN CONDITIONS

$V_Z = 30.0V$	
$I_Z =$	% P_D
83.0mA	50
166.0mA	100
208.0mA	125
250.0mA	150
291.0mA	175



NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of $\pm 1\%$ of the reading and $\pm$ one digit except for readings greater than 9.99mA which have an absolute accuracy of $\pm 2\%$ of the reading and $\pm$ one digit. The data also has a resolution for four digits. The standard deviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I - POWER STRESS DATA SUMMARY

Page 1 of 2

PARAMETER	$I_R = 10.0\text{mA}$ (MAX)	$B_V = 28.5\text{V}$ (MIN)	31.5V (MAX)	
CONDITIONS AND LIMIT	$@ V_R = 22.8\text{V}$	$@ I_Z = 85.0\text{mA}$		
IDENTIFICATION	SIEMENS	G.S.I.	SIEMENS	G.S.I.
INITIAL DATA				
MIN VALUE	4.12nA	1.49nA	29.22V	29.27V
MAX VALUE	150.00nA	192.00nA	30.75V	30.75V
MEAN	12.34nA	17.39nA	30.28V	29.92V
STD DEV	24.01nA	45.68nA	0.36V	0.36V
INTERIM DATA				
POWER 50 TO 125% Δ MEAN VALUE				
50% POWER				
50 Hours	+34.90nA	+32.57nA	0.00V	+0.01V
150 Hours	+29.23nA	+39.35nA	-0.03V	+0.01V
250 Hours	+46.46nA	+43.42nA	+0.07V	+0.04V
500 Hours	-1.77nA	+32.23nA	+0.19V	+0.27V
100% POWER				
550 Hours	-5.14nA	+13.66nA	+0.19V	+0.23V
650 Hours	*+624.39 μ A	+16.11nA	+0.07V	+0.17V
750 Hours	-3.97nA	+13.38nA	+0.13V	+0.17V
1000 Hours	-1.83nA	+62.38nA	+0.14V	+0.15V
125% POWER				
1010 Hours	+225.16nA	+611.31nA	+0.09V	-0.04V
1025 Hours	-2.59nA	+158.41nA	+0.11V	-0.02V
1050 Hours	-4.51nA	+175.21nA	+0.17V	+0.02V
1150 Hours	-5.02nA	+264.91nA	+0.21V	+0.07V
1250 Hours	-1.32nA	+402.41nA	+0.26V	+0.12V
1500 Hours	*+2.14mA	*+1.87mA	+0.23V	+0.15V

(continued on second sheet)



JANTX1N2989B

TABLE 4 (Cont'd)
GROUP I - POWER STRESS DATA SUMMARY

Page 2 of 2

(continued from first sheet)

PARAMETER	$I_R=10.0\mu A$ (MAX)		$B_V=28.5V$ (MIN) 31.5V(MAX)		
CONDITIONS AND LIMITS	@ $V_R=22.8V$		@ $I_Z=85.0mA$		
IDENTIFICATION	SIEMENS	G.S.I.	SIEMENS	G.S.I.	
INITIAL DATA					
MIN VALUE	4.12nA	1.49nA	29.22V	29.27V	
MAX VALUE	150.00nA	192.00nA	30.75V	30.75V	
MEAN	12.34nA	17.39nA	30.28V	29.93V	
STD DEV	24.01nA	45.68nA	0.36V	0.36V	
INTERIM DATA					
POWER 150 TO 175%					
Δ MEAN VALUE					
150% POWER					
1510 Hours	*+908.19nA	+43.91nA	+0.19V	+0.16V	
1525 Hours	+0.59nA	+101.31nA	+0.19V	+0.18V	
1550 Hours	-2.68nA	+204.11nA	+0.23V	+0.17V	
1650 Hours	+188.96nA	+309.11nA	+0.79V	+0.23V	
-----	-----	-----	-----	-----	
1750 Hours	Job Stopped	+504.71nA	Job Stopped	-1.48V	
2000 Hours	Job Stopped	*+1.11mA	Job Stopped	+0.13V	
175% POWER					
2010 Hours	Job Stopped	Job Stopped	Job Stopped	Job Stopped	
2025 Hours	Job Stopped	Job Stopped	Job Stopped	Job Stopped	
2050 Hours	Job Stopped	Job Stopped	Job Stopped	Job Stopped	
2150 Hours	Job Stopped	Job Stopped	Job Stopped	Job Stopped	
2250 Hours	Job Stopped	Job Stopped	Job Stopped	Job Stopped	
2500 Hours	Job Stopped	Job Stopped	Job Stopped	Job Stopped	
FINAL DATA					
MIN VALUE	5.74nA	1.01nA	29.33V	29.64V	
MAX VALUE	1.53μA	9.99mA	32.95V	30.66V	
MEAN	201.30nA	1.11mA	31.07V	30.06V	
STD DEV	459.10nA	3.14mA	1.18V	.25V	

NOTE: Catastrophic Rejects removed from data.

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	$I_R = 10\mu A$ (MAX)	$B_V = 28.5V$ (MIN) $31.5V$ (MAX)		
CONDITIONS AND LIMITS	@ $V_R = 22.8V$	@ $I_Z = 85.0mA$		
IDENTIFICATION	SIEMENS	G.S.I.	SIEMENS	G.S.I.
INITIAL DATA				
MIN VALUE	0.00nA	3.19nA	29.83V	30.10V
MAX VALUE	9.84nA	11.20nA	31.22V	31.28V
MEAN	1.77nA	6.19nA	30.60V	30.81V
STD DEV	2.12nA	1.98nA	.40V	0.29V
INTERIM DATA (INITIAL TO FINAL)				
Δ MEAN VALUE				
Total Hrs. Temp (T_A)				
160 Hours 75°C	+204.63nA	+4.08 μA	-0.08V	-0.01V
320 Hours 100°C	+81.46nA	*+637.59 μA	-0.14V	-0.16V
480 Hours 125°C	+317.43nA	-2.58nA	-0.23V	-0.19V
640 Hours 150°C	+62.05nA	*+713.69 μA	-0.28V	-0.24V
800 Hours 175°C	+48.60nA	+8.54nA	-0.32V	-0.22V
960 Hours 200°C	Job Stopped	+77.38nA	Job Stopped	+0.62V
1120 Hours 225°C	Job Stopped	Job Stopped	Job Stopped	Job Stopped
1280 Hours 250°C	Job Stopped	Job Stopped	Job Stopped	Job Stopped
1440 Hours 275°C	Job Stopped	Job Stopped	Job Stopped	Job Stopped
1600 Hours 300°C	Job Stopped	Job Stopped	Job Stopped	Job Stopped
FINAL DATA				
FINAL TEMP	175°C	200°C	175°C	200°C
MIN VALUE	0.04nA	3.61nA	29.74V	30.57V
MAX VALUE	72.50nA	473.00nA	30.78V	32.40V
MEAN	50.37nA	83.57nA	30.28V	31.43V
STD DEV	23.10nA	152.60nA	0.36V	0.67V

* NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA

TABLE 6
GROUP III TEMP STRESS II DATA SUMMARY

PARAMETERS	I _R =10.0μA (MAX)		B _V =28.5 (MIN) 31.5 (MAX)			
CONDITIONS AND LIMITS	@ V _R =22.8V		@ I _Z =85.0mA			
IDENTIFICATION	SIEMENS	G.S.I.	SIEMENS	G.S.I.		
INITIAL DATA						
MIN VALUE	3.00nA	0.92nA	30.19V	29.55V		
MAX VALUE	9.99mA	36.50nA	31.37V	30.95V		
MEAN	587.70μA	4.28nA	30.58V	30.20V		
STD DEV	2.35mA	8.60nA	0.33V	0.42V		
INTERIM DATA						
(INITIAL TO FINAL)						
Δ MEAN VALUE						
Total Hrs. Temp. (T _A)						
16 Hours 150°C	-587.69μA	+9.49nA	-0.08V	-0.07V		
32 Hours 175°C	-587.69μA	+757.82nA	-0.08V	-0.06V		
48 Hours 200°C	-587.69μA	+757.82nA	+0.70V	+0.44V		
64 Hours 225°C	587.68μA	+7.55μA	+0.63V	-0.43V		
80 Hours 250°C	*+1.91mA	*+908.20μA	*-6.33V	-0.27V		
96 Hours 275°C	Job Stopped	+60.76nA	Job Stopped	*-4.85V		
112 Hours 300°C		*+4.54mA		*-8.23V		
FINAL DATA						
FINAL TEMP	250°C	300°C	250°C	300°C		
MIN VALUE	0.24μA	6.68nA	10.07V	9.12V		
MAX VALUE	9.99mA	9.99mA	30.11V	30.86V		
MEAN	2.50mA	4.54mA	24.25V	21.97V		
STD DEV	4.32mA	4.97mA	8.37V	9.39V		

*NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA



JANTX1N2989B

TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		U N I T S	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
					POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
	MIN	MAX			Siemens	G.S.I.	Siemens	G.S.I.	Siemens	G.S.I.
I _R		10	μA		* +153.66	* +149.15	+14283	* +225.91	* -88.150	* +779.61
B _V	28.5	31.5	V		+1.17944	+0.0370	-.210	-.03333	* -1.0320	* -1.9243

* NOTE: Catastrophic reject(s) removed from data.



TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY

JAN TXIN2989B

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	1	A	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	1	A	0	-
100 hr.	0	-	0	-
250 hr.	3	A	3	A B
150% 10 hr.	1	A	0	-
15 hr.	0	-	0	-
25 hr.	0	-	1	B
100 hr.	2	B	0	-
100 hr.	Job Stopped		2	B
250 hr.			1	A
175% 10 hr.			Job Stopped	
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP TA	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	0	-	0	-
100°C	0	-	1	C
125°C	0	-	0	-
150°C	7	C	1	A C
175°C	2	C	0	-
200°C	Job Stopped		7	C
225°C			Job Stopped	
250°C				
275°C				
300°C				

NOTES:

A. $I_R > 1.0\text{mA}$ B. $B_V > 47.25\text{V}$

* C. VISUAL (OTHER THAN HANDLING)

* All visual catastrophic rejects have cracked glass at the cathode and the cathodes have detached.

GROUP III 16 HR. TEMP. STEPS

TEST STEP TA	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	-	0	-
175°C	0	-	0	-
200°C	1	B	0	-
225°C	5	B	0	-
250°C	2	A B	1	A B
275°C	Job Stopped		0	-
300°C			4	A

MFR "A" = SIEMENS

MFR "B" = GENERAL SEMICONDUCTOR INC.



TABLE 9 STEP STRESS PARAMETRIC

FAILURE SUMMARY

JAN TX1N2989B

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100 hr.	2	A	0	-
100 hr.	Job Stopped		0	-
250 hr.			0	-
175% 10 hr.			Job Stopped	
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP T _A	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75°C	0	-	1	B
100°C	0	-	0	-
125°C	0	-	0	-
150°C	0	-	0	-
175°C	0	-	0	-
200°C	Job Stopped		4	A
225°C			Job Stopped	
250°C				
275°C				
300°C				

GROUP III 16 HR. TEMP. STEPS

TEST STEP T _A	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	-	0	-
175°C	0	-	1	B
200°C	4	A C	0	-
225°C	2	A	1	B
250°C	1	B	0	-
275°C	Job Stopped		0	-
300°C			0	-

MFR "A" = SIEMENS

MFR "B" = GENERAL SEMICONDUCTOR INC.

NOTES: A. B_V maximum limit failureB. I_R maximum limit failureC. S/N 9364 removed from Group III Testing as a MIL-STD-19500 maximum B_V limit failure



APPENDIX A

FAILURE ANALYSIS

Power Stress



MSFC STEP-STRESS TEST
FAILURE ANALYSIS
DIODES

JANTX1N2989B

Date 21 November 1978

J/N 2CN242-33A P/N 1N2989B MFR Siemens

End Points: End Point:
14.25-47.25 1.0mA Max.

S/N	PIV -volts- @85mA	I_r @ 22.8 V.dc	V_f @ dc	Initial Rej. @ Test Seq. No.:	Initial Rej. for
9325	short	∞		25 (75%pwr. 1150Hrs.Tot)	I_R
9329	0.29	∞		29. (125%pwr. 1500 Hrs.Tot)	I_R
9330	short	∞		31 (150%pwr. 1510Hrs.Tot)	I_R

INTERNAL VISUAL INSPECTION

S/N 9325 reveals that bonding material has flowed up the internal lead (see Figure A-1). After chemical removal of the epoxy, the internal wire lead is not attached to the die.

S/N 9329 - the internal lead and top contact disc were off.

S/N 9330 - the internal lead and top contact disc were off.

*h trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable



MSFC STEP-STRESS TEST
FAILURE ANALYSIS
DIODES

JANTXIN2989B

Date 21 November 1978

J/N 2CN242-33A P/N 1N2989B MFR General Semiconductor

End Points: End Point:
14.25-47.25 1.0mA Max.

S/N	PIV -volts- @85mA	I_r @ 22.8 V.dc	V_f @ _____ dc	Initial Rej. @ Test Seq. No.:	Initial Rej. for:
9375	short	∞		29 (125% pwr. 1500Hrs.Tot)	I_R
9376	short	∞		29 (125% pwr. 1500 Hrs.Tot)	I_R
9384	9.4@250uA(S)	∞		31 (150% pwr. 2000Hrs.Tot)	I_R

INTERNAL VISUAL INSPECTION

S/N 9375 - the internal lead was off. The active cell is still attached to it.

S/N 9376 - the internal lead and top contact disc are off and the die is attached to the stud (see Figure A-2).

S/N 9384 - the internal lead was off with the die still attached to it.

* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

** h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable



JANTX1N2989B

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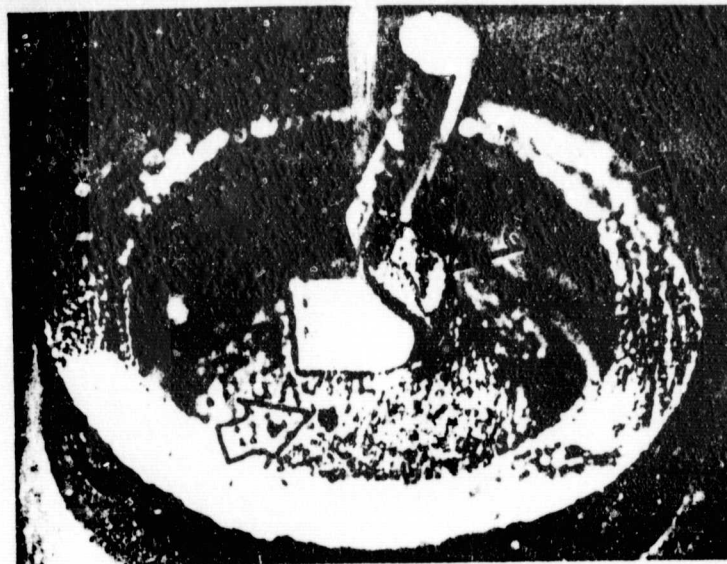


FIGURE A-1
S/N 9325, Siemens Device, 11X.
Arrows indicate metal ball in package and
metal flow on internal lead.

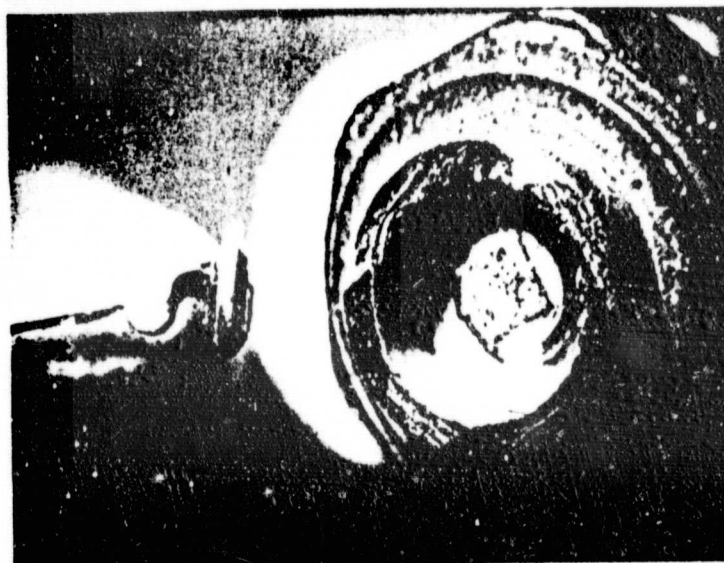


FIGURE A-2
S/N 9376, GSI Device, 6X. Die is still attached
to stud; top contact disc is attached to lead.



CONCLUSIONS

All of these General Semiconductor and Siemens devices were mechanically held together, as readings were obtainable, but the bonding material had melted and flowed away causing them to come apart when opened.

These Siemens and General Semiconductor devices failed due to excessive temperatures which melted the die bonding material. The die connections were damaged, and the bonding material alloyed with the silicon over long periods at high temperatures, causing electrical damage.



JANTX1N2989B

APPENDIX B

FAILURE ANALYSIS

Temperature Stress I



MSFC SITE STRESS TEST
FAILURE ANALYSIS

DIODES
(Temperature Stress I)

JANTX1N2989B

Date 21 November 1978

J/N 2CN242-33B P/N 1N2989B MFR General Semiconductor

End Points: End Point:
14.25-47.25 1.0mA Max.

S/N	PIV -volts- @ 85.0mA	I_r @ 22.8 V.dc	V_f @ dc	Initial Rej. @ Test Seq. No.:	Initial Rej. for
9344	*short	* ∞		13(200°C 960 Hrs.Tot)	Lead loose
9345	* 28V	*0.05uA		09(150°C 640 Hrs.Tot)	Lead loose
9350	*short	* ∞		05(100°C 320 Hrs.Tot.)	Lead loose
*Internally probed. External lead was open.					

INTERNAL VISUAL INSPECTION

S/N 9344 - the tubulation and internal wire lead have broken loose from the glass seal and die. The die is cracked. (See Figures B-1 and B-2)

S/N 9345 - the internal wire has become detached from the top of the die.

S/N 9350 - the die is detached from both the internal wire lead and stud.

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* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

** h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable



MSFC STEP-STRESS TEST
FAILURE ANALYSIS

JANTX1N2989B

DIODES
(Temperature Stress I)

Date 21 November 1978

J/N 2CN242-33B P/N 1N2989B MFR Siemens

End points: End point:
14.25-47.25 1.0mA Max.

S/N	PIV -volts- @ 85.0mA	I_r @ 22.8 V.dc	V_f @ ___ dc	Initial Rej. @ Test Seq. No.:	Initial Rej. for
9397	*short	*		09 (150°C 640 Hrs. Tot)	Lead loose
9400	* 27V	-open- *1.8uA		09 (150°C 640 Hrs. Tot)	Lead loose
9403	*short	*		09 (150°C 640 Hrs. Tot)	Lead loose
*Internally probed. External lead was open.					

INTERNAL VISUAL INSPECTION

S/N 9397 and 9403 - the active cell is detached from the internal wire lead and stud. (See Figure B-3).

S/N 9400 - the die and top contact disc have come detached from the stud and the tubulation is loose in the glass seal.

* h_{FE} trace present. Cannot meet stated test conditions. (Leaky)

** h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable



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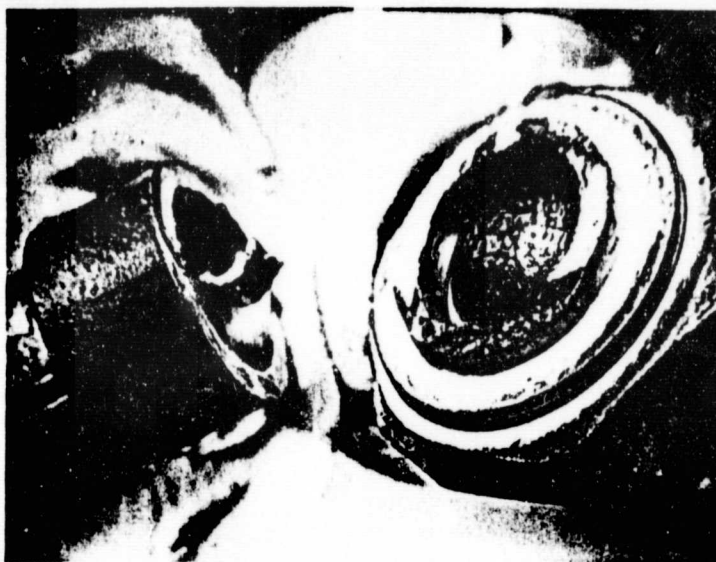


FIGURE B-1
S/N 9344, General Semiconductor Device, 5X.
See Figure B-2 for close-up of cracked die.

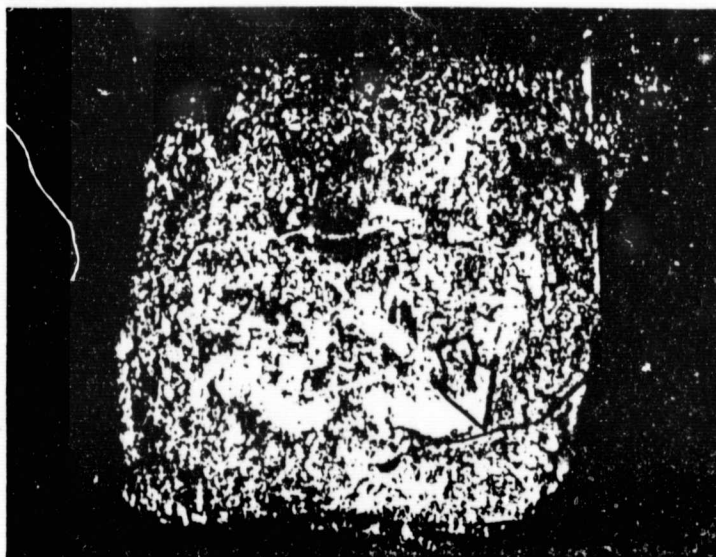


FIGURE B-2
S/N 9344, General Semiconductor Device, 40X.
Arrow indicates crack in die.

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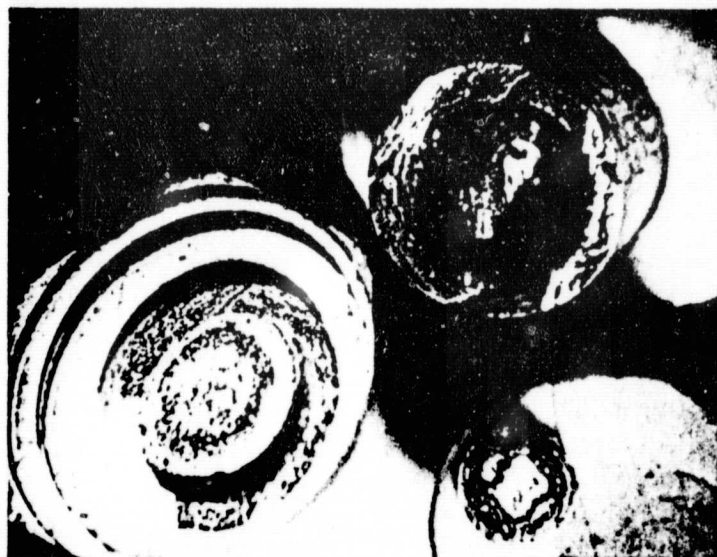


FIGURE B-3

S/N 9403. Siemens Device, 5X.

Die and contact disc have come loose from the
internal wire lead and stud.



CONCLUSIONS

These devices failed due to excessive temperature.

General Semiconductor S/N 9344 and 9345, and Siemens S/N 9400 failed due to exposure to temperatures above the melting point of the lead bonding material, which resulted in disconnection of the internal wire lead. General Semiconductor S/N 4344 also exhibits a die crack due to excessive heat.

All the other General Semiconductor and Siemens devices failed because the bonding material alloyed with the silicon causing junction shorts.